Center for Advanced Computing and Communication (CACC)

North Carolina State University and Duke University

A National Science Foundation Industry/ University Cooperative Research Center since 1994

Advancements in communications and signal processing benefit many industries

Center Mission and Rationale

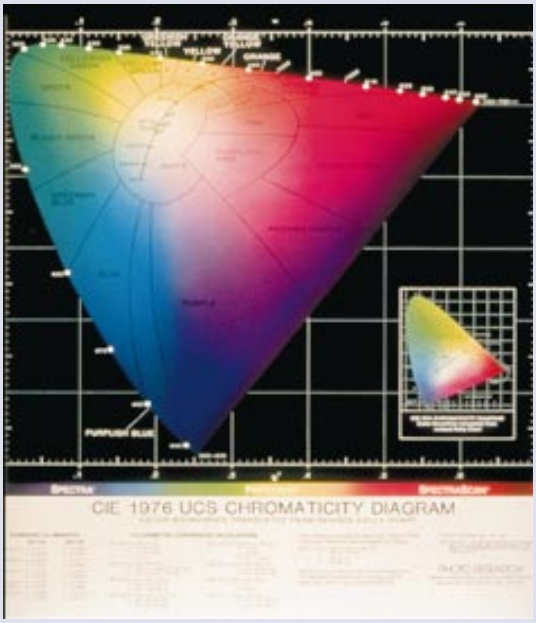
Telecommunications technology and high speed computing are increasingly important in everyday life. Computers are performing bigger, more complex tasks. Global communications systems are used by everyone from CEOs to school children. Military operations are carried out by computers requiring highly reliable software. At the Center for Advanced Computing and Communications (CACC), multidisciplinary teams of researchers are meeting these challenges by helping to develop technologies which improve the quality of life.

The Center's mission is to carry out basic and applied research on fundamental problems with both industrial and academic relevance, to transfer these results to our members, and to provide our students with a unique and challenging educational opportunity. Our research goal is to create concepts, methods, and tools for use in the analysis, design, and implementation of advanced computer and communication systems.

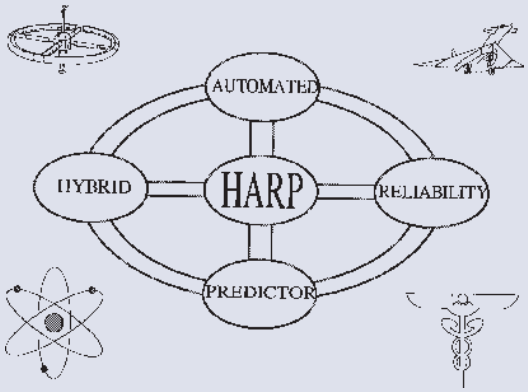
Research Program

The Center for Advanced Computing and Communication was originally founded at North Carolina State University in 1982 as the Industry/University Cooperative Research Center for Communications and Signal Processing (CCSP). Merging with a research team from Duke University in 1994, the Center enhanced its research capabilities in the networking area and introduced expertise in distributed algorithms and dependable systems.

CACC consists of more than 20 faculty members and their graduate students involved in cutting-edge research in five primary areas: High Speed Networking, Fault-Tolerant Systems, Image Processing, Distributed Algorithms and Systems, and Digital Communications and Optimization. The Center routinely sponsors industrial and international visiting scholars for periods of several weeks to a year. Recent visitors have included researchers from France, Germany, Italy, Japan, Russia, Sweden, Spain, and Turkey.



Used with permission of Photo Research



CACC researchers at Duke are known for development of reliability and performability modeling tools, including HARP and SHARPE.

High Speed Networking

Working with the major telecommunications producers, CACC has helped chart the course of network development for over a decade. Research in the area of network performance has resulted in key theoretical and analytical contributions to the modeling, prediction, and simulation of telecommunications networks. Simulations and analyses of end-to-end performance of asynchronous transfer mode (ATM) and private broadband networks increased understanding of the trade-offs between packet and cell switching. The Center participated in a major IBM project to develop software for evaluating potential computer and communications networks. One of the CACC researchers involved in this project received IBM's 1992 Outstanding Achievement in Research Award. Software provided to another member company enables them to simulate the call-carrying capacity to their switches. CACC's participation in the development of the North Carolina Information Highway (NCIH) provides direct access to the most advanced telecommunications testbed in the U.S. Current work includes—

- Development of tools for determining performance parameters of communication networks
- Specification, verification, and validation of communications protocols
- Traffic measurements on existing networks and accurate traffic models for future networks
- Solving quality-of-service and interoperability problems
- Developing a scalable all-optical switch architecture with end-to-end optical paths

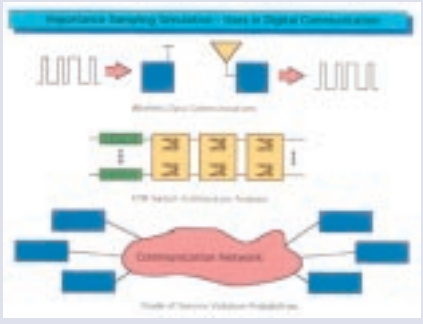
- Designing and implementing control protocols for secure systems.

Fault-Tolerant Systems
CACC faculty are internationally renowned for their work in Markov chains, stochastic Petri nets, and queuing networks. This expertise has been applied to the development of reliability and performability modeling tools (HARP, SHARPE, SPNP) by numerous industrial and governmental laboratories. A reliable and fault-tolerant clocking mechanism has also been adapted to a commercial flight-control system and to a real-time weapon-control application. Industry is under pressure to speed up the product development cycle. In response, the Center is meeting the need for tools to evaluate processes and ensure product quality. We are currently developing—

- Reliability and performability modeling tools leading to an integrated modeling environment
- A fault-injection testbed for the validation of highly reliable complex systems
- Emulation and rapid prototypes of complex fault-tolerant systems
- Analyses and design of highly reliable real-time systems
- Design and implementation of highly testable systems
- Development of a toolset for evaluation and control of software processes.

Image Processing
In applications from health care to textiles, multimedia-based education to electronic publishing, digital images are everywhere. Researchers at CACC are applying signal processing expertise to a variety of imaging problems including image-signal reconstruction and restoration, color science, motion estimation, and nonlinear optimization. Recent work in scanning filter design resulted in development of a high-precision machine tool which is currently used by a member company to produce images with highly accurate color quality, against which all their other color quality equipment is measured. CACC is currently —

- Developing a signal processing foundation for solving color system problems, including design of color scanning filters, better methods for color correction, improved image/video compression, and improved calibration techniques
- Extending the basic methods for dealing with nonlinear systems
- Developing optimization techniques for image models and restoration
- Utilizing the characteristics of the human visual system to improve the performance of color systems
- Developing improved quality measures for assessing color system performance.



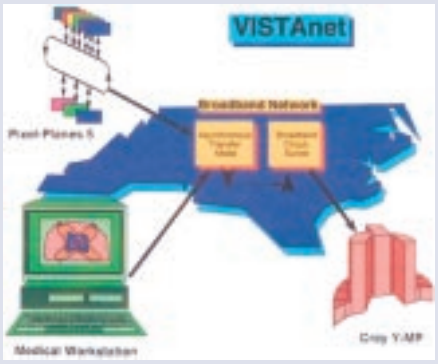
CACC is investigating both wired and wireless communication architectures.

Distributed Algorithms and Systems
Computer communications and networking will remain the fastest-growing segment of the computer industry during the 1990s. CACC's work on high performance distributed computing systems involves evaluating their potential as a cost-effective, high performance computional platform and their adaptability in the presence of failures or widely varying workload conditions. This group is concentrating on —

- Implementation of parallel algorithms for scientific and commercial applications
- Use of workstation clusters as cost-effective parallel computers
- Techniques for load-balancing for parallel computers and parallel discrete-event simulation.

Digital Communications and Optimization
Advances in technology have led to a new generation of communication systems, including cellular telephony, personal communications services, high-speed optical fiber communications links, and mobile satellite communications. These advances require analysis of new algorithms and coding schemes for wireless communications. Faster, cheaper computing has enabled researchers at CACC to develop novel techniques for efficient simulation and optimization of these increasingly complex systems. Speedup factors of up to 14 orders of magnitude have been obtained for computer simulations using statistically optimized importance sampling techniques. CACC researchers have developed a general theory of Simulated Annealing and accelerated versions with speed-up factors up to 50. Annealing methods have been applied successfully to image processing, communications, computer aided design, and neural networks.

- Techniques for efficient simulation-based performance analysis of communication systems, including —
  1) RF links with multipath fading channels and adaptive equalizers
  2) High-speed, low error-rate optical communications links
  3) Cell loss probability analysis of communications networks, including ATM networks



CACC is a participant in the VISTAnet gigabit tested.

- Optimization techniques for computer-aided design of digital filters, communications networks, and communications channels
- Multiuser detection algorithms for spread-spectrum mobile cellular networks
- Modulation and demodulation methods and diversity-combining techniques for fading multipath channels
- Adaptive equalization and coding for cellular radio.

Center Headquarters

NC State Univ. Site Director: Wesley E. Snyder
Box 7914
North Carolina State University
Raleigh, NC 27695-7914
Phone: (919) 515-3015
Fax: (919) 515-2285
E-mail: wes@eos.ncsu.edu
Web: http://www.ece.ncsu.edu/cacc/

Duke Site Director: Kishor S. Trivedi
Box 90291
Duke University
Durham, NC 27708-0291
Phone: (919) 660-5269
Fax: (919) 660-5293
E-mail: kst@ee.duke.edu

Center Evaluator: Dr. Denis Gray
Department of Psychology
North Carolina State University
Raleigh, NC 27695-7801
Phone: (919) 515-1721
Fax: (919) 515-1716
E-mail: denis_gray@ncsu.edu

NSF 93-97ll (rev. 7/9